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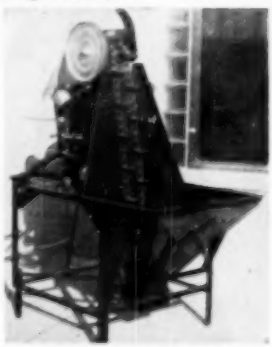

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COOPERATIVE POTATO VARIETY TRIALS IN MAINE[1]

C. E. Cunningham[2], R. V. Akeley[3], and K. F. Nielsen[4]

After crosses of various varieties of potatoes are made in Beltsville, Maryland, numbered seedling varieties of potatoes are sent to Maine for growing on the Chapman Farm in Aroostook County. These new seedlings are grown under controlled conditions and are observed throughout the growing season for such things as growth habits, disease resistance and susceptibility to insect attack. At harvest, note is made of tuber set, tuber characteristics, yield and specific gravity.

Seedlings that measure up to predetermined standards are saved for further observations and increase. The seedlings that withstand the rigors of this early testing are eventually turned over to the Agronomy Department of the Maine Agricultural Experiment Station for testing in variety trials which are conducted under regular field conditions.

The major portion of the data reported in this paper was collected from this latter type of trial. In this particular trial fourteen named varieties and fourteen unnamed varieties were grown under uniform conditions at Aroostook Farm, Presque Isle, Maine. The varieties were grown in plots 30 feet long and replicated four times in a randomized-block design. Tubers from all plots were harvested and sorted into several different size classes. Total solids content of tubers was calculated from a specific gravity determination made on a sample of twenty tubers from each replicate.

Yields and Quality

A satisfactory yield of good-quality potatoes is one of the most important factors of production that the grower needs to consider. Efficiency of production of marketable tubers per acre will determine to a large degree the success of the individual who grows potatoes. Therefore, the introduction of varieties that contribute to efficient production of good-quality potatoes because of disease resistance and yielding ability is extremely important to the potato grower.

Evaluation of varieties has to be based on factors besides yield. One of these is the total solids content of the tubers. Specific gravity determinations provide a convenient method of estimating the total solids content. A high specific gravity indicates a high total solids content and generally a more mealy potato. Potatoes to meet various consumer demands can be classified into the following specific-gravity classes:

Specific Gravity	
1.060-1.069	Poor French fryers, poor bakers, fair boilers, good pan fryers.
1.070-1.079	Fair French fryers, fair bakers, good boilers, fair pan fryers.
1.080 and above	Good French fryers, good bakers, fair boilers, fair pan fryers.

[1]Accepted for publication October 1, 1955.

[2]Assistant Agronomist, Maine Agricultural Experiment Station, Orono, Me.
[3]Senior Horticulturist, Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, Washington, D. C.
[4]Formerly, Assistant Agronomist, Maine Agricultural Experiment Station, now, Senior Agronomist, Central Experimental Farm, Ottawa, Canada.

The varieties are listed in table 1 in descending order of yields. The Saco and Kennebec varieties produced high yields of tubers with a high specific gravity. The fact that tubers of the Saco variety tend to be misshapen in some seasons may limit its value as a tablestock variety. However, because of its large yield potential it may still produce more marketable tubers per acre than some of the lower yielding varieties. The Saco variety shows particular promise for processing because of the high solids content of its tubers and the relatively slow accumulation of reducing sugars when stored at low temperatures.

The Kennebec variety produces good yields of tubers high in solids. Experimental results and grower experience indicate that the tubers of the Kennebec variety are susceptible to skinning and bruising, particularly when the rates of nitrogen fertilization are high. Therefore, precautions have to be taken to be sure that tubers are allowed to "harden" in the ground before harvest.

Merrimac and Delus are new varieties that produce satisfactory yields of tubers high in solids. Neither variety has been grown commercially to date, but both varieties show sufficient promise to warrant testing under commercial conditions as soon as seed is available.

The Russet Burbank and Early Gem varieties were the only two deeply russeted varieties included in the trial. Because of its low yield and poor quality, the Early Gem is unsatisfactory under Maine conditions. The Russet Burbank produced relatively low yields of tubers high in solids. This variety is of particular importance to growers interested in producing potatoes to satisfy the demand for the long russet type of tubers in the markets.

Cherokee, a relatively new variety, gave satisfactory yields of good-quality potatoes. Reports indicate that this variety has received good acceptance in the markets, particularly when washed prior to shipment.

Several other varieties included in the trial gave greater yields than Maine's most important variety, the Katahdin, and they were as good or better than the Katahdin on the basis of total solids. Pungo has been grown commercially to a limited extent mainly as a seed variety. This variety has a tendency to produce hollow heart tubers under our conditions, a fault which may limit its use.

B595-76, although a moderate yielder, shows promise because of its high quality and disease resistance. B355-35 produces good yields of tubers relatively high in solids. Plymouth (B73-10) produces high yields of medium-quality tubers resistant to scab.

Maturity

Varieties are classified in table 1 as to whether they are early, medium or late maturing. Potato maturity is important in a variety from two standpoints. First, a variety must produce good yields during our short season. Yields may not be satisfactory in seasons when a killing frost occurs early if the variety is extremely late maturing. Also, the danger of losses from field frost is greater if harvest is delayed to allow the variety to attain satisfactory yields. Second, the variety should not be so late in maturing that the tubers are immature and susceptible to excessive skinning and bruising at harvest time. Proper use of nitrogen fertilizer

TABLE 1.—*Important characteristics, yields, specific gravities, and total solids contents of varieties in 1954 trial.*

	Skin Color	Maturity	Disease Resistance	Yield of Tubers above 1.50 Inches	Specific Gravity	Total Solids
				Bushels per Acre		Per cent
Saco	White	Late	Late blight (V, A & X, Net)	644	1.082	20.6
Plymouth (B73-10)	White	Late	Late blight, scab	606	1.074	18.9
Kennebec	White	Late	Late blight (V, A & Net)	604	1.082	20.6
Pungo	White	Late	Late blight	573	1.078	19.8
B355-35	White	Late	Late blight (R. R. & V. A)	567	1.077	19.6
Cherokee	White	Medium	Late blight, scab	509	1.079	20.0
Merrimack[2]	White	Late	Late blight (R. R., V. A & Net)	492	1.086	21.5
Canso	White	Late	Late blight	476	1.077	19.6
Keswick	White	Late	Late blight	473	1.080	20.2
B2952-1	White	Late	Leaf roll	472	1.074	18.9
Houma[2]	White	Late	Virus A, leaf roll Wilt)	465	1.075	19.2
Delus	White	Late	Late blight	465	1.087	21.7
Green Mountain	White	Late	None	462	1.084	21.1
B911-21	White	Early	Ring rot	462	1.069	17.9
B595-76	White	Medium	Late blight (V.A & X, Scab & Wilt	461	1.084	21.1
B920-7	White	Early	Late blight, scab	460	1.070	18.1
B2357-13	White	Medium	Leaf roll	456	1.066	17.3
B931-19	White	Late	Ring rot	447	1.075	19.2
B2091-12	White	Late	Leaf roll	436	1.067	17.5
B962-3	White	Medium	Late blight, scab	432	1.080	20.2
B766-a	White	Late	Ring rot	402	1.066	17.3
Katahdin	White	Late	Virus A, leaf roll (Net)	400	1.073	18.7
Russet Burbank[3]		Late	Scab	399	1.080	20.2
B911-31	White	Late	Ring rot	396	1.070	18.1
Early Gem		Early	Scab	371	1.068	17.7
B2395-30	White	Early	Ring rot	360	1.068	17.7
B2938-17	White	Early	Leaf roll	359	1.072	18.5
B751-119	White	Medium	Leaf roll	357	1.078	19.8
			L.S.D. 5 per cent level	77	0.004	0.8
			L.S.D. 1 per cent level	102	0.005	1.0

[1]Varieties arranged in descending order of yields.
[2]Seedpieces of Houma and Merrimack varieties spaced at 10 inches.
[3]Seedpieces of Russet Burbank variety spaced at 14 inches, and other varieties spaced at 8.

V.=Virus
Net=Net necrosis
R.R.=Ring rot
Wilt=Verticillium wilt

and vine killing aid in conditioning tubers for harvest. However, it is still essential that the variety condition readily.

It would be desirable for a variety to be early in maturity and to produce high yields of tubers high in total solids. The early varieties very often produce rather low yields of tubers relatively low in solids. Two varieties of medium maturity, Cherokee and B595-76, produced moderate to good yields of high-quality tubers.

Disease Resistance

The resistance of the individual varieties to various diseases determined by tests in previous years is given in table 1. Thirteen varieties included in the trial have demonstrated their resistance to the common race of the late blight organism. The presence of other races of the blight organism makes necessary an adequate spray program if these resistant varieties are grown. However, resistance to the common race of late blight is important, for the common race is apparently still the most prevalent in the potato growing areas of Maine.

Seven varieties grown in the 1954 variety trial have resistance to the mosaic virus A. Two varieties, Saco and B595-76, are immune from the latent mosaic virus X. Resistance to virus A eliminates mild mosaic in the field, for mild mosaic is the result of infection of growing plants with both viruses A and X. Resistance to virus X, in addition to the elimination of mild mosaic, results in the elimination of rugose mosaic in the field, for rugose mosaic is the result of infection of growing plants with viruses X and Y. The presence of virus X cannot be detected usually by visual symptoms in the field. Therefore, plants infected with virus X alone cannot be removed by "roguing". Even though the latent mosaic virus is not apparent under field conditions, the virus is responsible for yield reductions.

Growers continue to sustain losses because of tuber infection with the organism causing common scab. Although the incidence of scab can be controlled to some degree by maintaining the pH of soils below 5.5, this method of control is not entirely adequate. The most effective method to control common scab on soils that continue to give trouble is the use of scab-resistant varieties. For those growers interested in a round, white variety resistant to scab, Cherokee is probably the most satisfactory choice. The variety is not immune to scab but will produce clean tubers on soils where it is impossible to produce clean tubers of a susceptible variety. The Russet Burbank variety apparently has considerable scab resistance and will do well on soils having a pH high enough to produce scab on non-resistant varieties.

Plymouth (B73-10) and B595-76 have resistance to common scab and show sufficient promise from a yield and quality standpoint to be tested further.

The maintenance of clean seed stocks and adequate sanitation programs have been responsible for the present control of ring rot. However, ring rot is still responsible for losses to growers each season. The introduction of ring-rot-resistant varieties offers a greater opportunity for control of this destructive disease than now exists. Of the existing commercial varieties, Teton is one of the more acceptable varieties resistant to ring

rot. It produces moderate yields of attractive tubers that are uniform in size. The solids content of the tubers of Teton variety is very near that of Katahdin when produced under similar conditions. Merrimack and B355-35 are ring-rot-resistant varieties that produce acceptable yields of good-quality potatoes. B911-21 is an early ring-rot-resistant variety which yielded better than the Katahdin. The tubers, however, tended to be of slightly poorer quality.

Resistance to leaf roll and net necrosis is still important even though the development and use of effective insecticides to control aphids have aided greatly in the control of leaf roll.

Data in table 1 indicate that considerable progress has been made in the combination of resistance to various diseases with high yields of good-quality tubers in a single variety.

Size of Tubers

Each year the size of tubers is becoming more important in the marketing of potatoes. Many purchasers of potatoes have specific size requirements for their needs and request that potatoes be sized before shipment. In addition, results of recent consumer-preference studies indicate that consumers prefer potatoes of a uniform medium size. Therefore, it is important that growers use production practices that will result in satisfactory yields of tubers of the most desirable size. One must recognize that different varieties will require different production practices to give the same yield of uniform medium size tubers.

The data in table 2 show the distribution of tubers from the different varieties into five size ranges. Potato yields are functions of number and size of tubers. If tuber numbers are constant, an increase in size is reflected by an increase in yield. Conversely, if yields are at the same level, an increase in number of tubers is reflected by a smaller average size of tubers.

Seasonal conditions affect very markedly the numbers of tubers that a variety produces. Perhaps the most important factor that we can control effectively is the spacing of seedpieces in the row. Different varieties require different seedpiece spacings because of differences in their ability to "set" tubers. For instance, the data in table 2 show that when the Saco variety had seedpieces spaced at eight inches it had 76 per cent of its 644-bushels yield of tubers below 2.50 inches in diameter. At the same eight-inch spacing, 56 per cent of the 604-bushel yield of the Kennebec variety was below 2.50 inches in diameter. One would conclude on the basis of the results that to produce higher percentages of yield of tubers above 2.50 inches, seedpieces of the Saco variety should be spaced farther apart than those of the Kennebec.

Seedpiece spacings of 8, 10, 12, and 14 inches were compared for the Canso, Cherokee, and Teton varieties this past season. Yields above 1.50, 2.00, and 2.50 inches are given in table 3. The data show a general trend toward reductions in yields of tubers above 1.50 inches and above 2.00 inches in diameter as the distance between seedpieces was increased. The yields of tubers above 2.50 inches in diameter increased in general as the distance between seed pieces was increased. If these varieties were produced for tablestock with no available market for the extremely small

TABLE 2.—*Distribution of yields of tubers above 1.50 inches in diameter into size clases.*

Variety	Yield above 1.50 Inches	Tubers in Indicated Size Class				
		1.50-2.00 Inches	2.00-2.50 Inches	2.50-2.88 Inches	2.88-3.25 Inches	Over 3.25 Inches
	Bu. per Acre	Per cent	Per cent	Per cent	Per cent	Per cent
Saco	644	8.9	66.8	20.2	3.7	0.4
Plymouth (B73-10)	606	5.4	56.9	30.9	6.0	0.8
Kennebec	604	5.1	51.0	39.1	4.4	0.4
Pungo	573	9.3	61.3	24.2	4.7	0.5
B355-35	567	10.9	64.7	21.0	2.6	0.8
Cherokee	509	13.1	64.6	18.3	3.8	0.2
Merrimack	492	6.7	59.1	31.7	1.9	0.6
Canso	476	7.7	69.3	21.4	1.6	..
Keswick	473	5.5	44.5	31.9	16.3	1.8
B2952-1	472	8.9	58.3	27.1	3.4	2.3
Houma	465	14.6	69.6	15.1	0.7	..
Delus	465	3.3	38.2	47.1	10.3	1.1
Green Mountain	462	13.6	74.2	11.9	0.3	..
B911-21	462	8.7	68.2	21.5	1.6	..
B595-76	461	19.6	72.9	7.3	0.2	..
B920-7	460	15.2	73.4	10.6	0.8	..
B2357-13	456	17.2	71.2	11.2	0.4	..
B931-19	447	7.5	56.7	30.0	5.8	..
B2091-12	436	8.9	64.0	21.8	5.3	..
B962-3	432	18.7	62.9	14.9	2.7	0.8
B766-a	402	8.4	57.0	30.5	4.1	..
Katahdin	400	8.6	62.3	24.2	4.5	0.4
Russet Burbank[1]	399	33.6	64.5	1.9	..	..
B911-31	396	15.4	70.0	13.2	1.4	..
Early Gem	371	15.8	68.4	14.4	1.4	..
B2395-30	360	15.6	72.7	10.4	0.7	0.6
B2938-17	359	10.2	64.8	21.9	3.1	..
B751-119	357	20.1	68.6	10.0	1.2	0.1

[1]The average weight in ounces of tubers of the Russet Burbank variety in the size classes was as follows: 1.50-2.00 inches—2 ounces; 2.00-2.50 inches—3.2 ounces; and 2.50-2.88 inches—7.3 ounces.

tubers, a seedpiece spacing greater than 8 inches would be desirable.

Close spacing of seedpieces is very effective in controlling oversize of potatoes for sale as seed, for small potatoes are in demand for seed. However, small potatoes are less valuable for tablestock. Greater distances between seedpieces in tablestock plantings combined with the use of vine killers to control oversize will result in the production of tubers of larger size, particularly with those varieties that "set" heavy.

Tuber size of the Russet Burbank variety is extremely important. The larger tubers are in demand for baking and substantial price premiums are paid. The Russet Burbank variety was grown with seedpiece spacing of 14 and 18 inches. A seedpiece spacing of 18 inches produced a greater percentage of the larger size tubers. There is some evidence to indicate that the use of extremely small potatoes of the Russet Burbank variety for seed may not be as desirable as it is with some of the round, white varieties. The variety produces a large number of tubers, and the use of small whole tubers and seedpieces cut from small tubers will result in larger numbers of tubers and an accompanying decrease in tuber size.

TABLE 3.—*Effect of seedpiece spacing on yields and size of potato tubers.*

Variety	Spacing	Yields of Tubers of Indicated Size		
		Above 1.50 Inches	Above 2.00 Inches	Above 2.50 Inches
	Inches	Bus. per Acre	Bus. per Acre	Bus. per Acre
Canso	8	533	497	266
	10	513	492	318
	12	497	479	342
	14	496	479	349
L.S.D.	5-Per cent level	N.S.	N.S.	62
	1-Per cent level	--	--	83
Cherokee	8	561	537	341
	10	551	529	365
	12	505	486	356
	14	498	486	396
L.S.D.	5-Per cent level	47	49	62
	1-Per cent level	63	--	83
Teton	8	553	523	268
	10	537	508	306
	12	508	490	346
	14	496	482	334
L.S.D.	5-Per cent level	47	N.S.	62
	1-Per cent level	63	--	83

Nitrogen was applied at planting at rates of 60 to 210 pounds per acre. Results in table 4 indicate that yields and size of tubers increased up to the application of 180 pounds of nitrogen per acre. Response to this amount of nitrogen might not be obtained in years of more normal rainfall.

Since the weight of the tubers in a given size class is often times as important when considering the Russet Burbank as the diameter in inches, the average tuber weight for each size class was determined. It was found that the average tuber weights were 2.2, 4.3, 8.4, 12.0 and 16.0 ounces for the 1.5 to 2.0, 2.0 to 2.5, 2.5 to 2.88, 2.88 to 3.25 and over 3.25 inch class.

STORAGE CHARACTERISTICS

The major portion of the Maine crop is stored and marketed during the winter and spring months. Early sprouting and the resultant loss during storage affect the value of a potato variety. Sprouting can be effectively controlled by maintaining storage temperatures below 40°F. This is rather difficult in the present commercial storages during the spring months.

Twelve varieties grown in the 1953 test were placed in controlled storages immediately after harvest. The effects of temperature and humidity on the sprouting and weight loss are given in table 5. Ontario, Pungo, and Saco sprouted the earliest and revealed the largest weight loss.

SUMMARY

Twenty-eight potato varieties were grown in a yield test at Presque Isle, Maine, in 1954. Twenty-seven varieties had demonstrated resistance in previous trials to one or more of the following diseases: late blight, virus

TABLE 4.—*Effects of nitrogen fertilization and seedpiece spacing on yield and tuber size of Russet Burbank potatoes.*

Fertilizer Grade[1]	Spacing	Yield per Acre of Tubers of More Than 1.50 Inches	Tubers in Indicated Size Class				
			1.50-2.00 Inches	2.00-2.50 Inches	2.50-2.88 Inches	2.88-3.25 Inches	More Than 3.25 Inches
	Inches	Bushels	Per cent	Per cent	Per cent	Per cent	Per cent
3-9-9	14	303	56.6	42.5	0.9	..	..
	18	280	35.0	60.5	4.1	0.4	..
4½-9-9	14	310	35.9	63.0	1.1	..	..
	18	294	18.1	71.0	10.0	0.9	..
6-9-9	14	367	34.9	58.1	5.5	0.9	0.6
	18	354	16.6	72.3	11.1	..	..
7½-9-9	14	344	22.2	69.2	8.6	..	..
	18	382	17.9	74.1	8.0	..	..
9-9-9	14	372	25.2	66.7	8.1	..	..
	18	393	15.3	73.8	10.9	..	..
10½-9-9	14	382	16.7	71.0	11.8	0.5	..
	18	378	14.0	70.0	14.7	0.6	0.7

[1]Fertilizer applied at 2000 pounds per acre.

TABLE 5.—*Effect of storage temperature and humidity upon sprouting and weight loss of 12 potato varieties, 1953-1954.*

Variety	December 14, 1953			February 15, 1954			April 19, 1954		
	38°F. 80 Per cent R.H.[1]	45°F. 75 Per cent R.H.	50°F. 70 Per cent R.H.	38°F. 80 Per cent R.H.	45°F. 75 Per cent R.H.	50°F. 70 Per cent R.H.	38°F. 80 Per cent R.H.	45°F. 75 Per cent R.H.	50°F. 70 Per cent R.H.
	Average Length of Sprouts			Average Length of Sprouts			Total Shrinkage[2]		
	Inches	Inches	Inches	Inches	Inches	Inches	Per cent	Per cent	Per cent
Green Mountain	..	..	..	..	0.25	3.00	8.3	11.0	23.0
Ontario	..	0.50	2.00	S[3]	1.50	7.00	10.8	15.7	28.5
Katahdin	..	..	0.50	..	1.00	2.50	6.7	12.2	26.0
Kennebec	..	..	..	..	0.50	3.00	6.6	10.7	22.1
Cherokee	..	..	0.75	..	0.75	4.00	5.8	10.6	22.4
Russet Burbank	..	..	..	..	..	1.00	4.2	7.6	13.5
Teton	..	..	0.50	..	1.50	2.00	5.6	8.3	14.0
Pungo	..	0.25	2.50	S[3]	3.50	10.00	5.7	23.5	41.6
B355-35	..	..	..	..	0.50	1.50	7.2	12.4	22.0
Saco	..	0.25	2.00	S[3]	2.50	6.00	5.9	18.3	34.1
Delus	..	..	S[3]	..	0.25	1.50	5.9	9.7	17.5
Early Gem	..	..	..	..	0.12	1.00	3.2	5.9	16.5

[1]R.H. designates relative humidity.
[2]Calculated as per cent of weight October 9, 1953. Total shrinkage represents combined loss due to moisture loss, respiration and removal of sprouts.
[3]S indicates that tubers were starting to sprout.

A, virus X, common scab, ring rot, leaf roll, net necrosis, and *Verticillium* wilt.

Yields, specific gravity and size of tubers were determined for all varieties. Three varieties were grown in a seedpiece spacing test where distances between seedpieces were varied from 8 to 14 inches. The Russet Burbank variety was grown with seedpiece spacings of 14 and 18 inches. Nitrogen applications of 60 to 210 pounds per acre were made at planting of the Russet Burbank variety.

Twelve varieties grown in 1953 were stored at temperatures of 38°, 45° and 50°F. Sprout observations and shrinkage determinations were made upon removal from storage.

Yields for the varieties tested varied from a high of 644 bushels per acre for the Saco variety to a low of 357 bushels per acre for B751-119. The Katahdin variety was well down the list with a yield of 400 bushels per acre.

Specific gravity of the tubers produced, ranged from 1.087 for Delus to 1.066 which was obtained for two numbered seedlings, B2357-13 and B766-a.

Sizing data show that the Russet Burbank had 33.6 per cent of its yield in the 1.50 to 2.0 inch size class with 0 per cent in the 2.88 inch or over classes. On the other hand, Canso had only 7.7 per cent of its tubers in the small size, whereas 18.1 per cent were placed in the larger classes.

The Russet Burbank variety responded to 180 pounds of nitrogen in the 1954 growing season.

High temperatures (50°F.) and low humidity (70 per cent R.H.) produced the greatest shrinkage in storage. Varieties showed considerable variation in the amount of shrinkage that occurred under these conditions.

THE INFLUENCE OF VARIETY ON THE SPECIFIC GRAVITY-MEALINESS RELATIONSHIP OF POTATOES[1]

ALLEN E. SCHARK[2], C. E. PETERSON[3], AND FRANCES CARLIN[4]

The principle of estimating starch and dry matter content from the specific gravity of potato tubers has been known for many years. As early as 1852, Pohl (7) calculated the starch content of potatoes from their specific gravity. In 1877, Holdefleiss (5) and Heiderpriem (4) presented tables for the estimation of starch and dry matter of potatoes from their specific gravity. Later in 1879, Behrend, Maercker, and Morgan (1) presented a more accurate set of specific gravity-starch content tables that are the basis of the tables in use at the present time.

In all the above papers, the authors indicated that the relationship between specific gravity and dry matter was not exact, but that the relationship was close enough for practical purposes.

Most investigators have accepted the concept that high dry matter content of potatoes as measured by specific gravity is highly correlated with mealiness of the cooked product. In general, mealy or the dry, flaky texture of cooked potatoes is often regarded as the most important, or most reliable criterion of quality. Because of the ease of estimating dry matter content by means of specific gravity determination, this method is widely used. During the past ten years much experimental work on the influence of variety, environment, storage, and cultural factors has utilized the specific gravity method as the sole means of estimating cooking quality. Because of the widespread use of this method, high specific gravity has become synonymous with high cooking quality.

However, in the process of testing specific gravity of hundreds of lots of potatoes over a period of five years, it became apparent that in evaluating cooked potatoes for mealiness some varieties were higher and some lower than their dry matter content would indicate. Our personal preference for certain varieties for cooking purposes did not always agree with ratings based upon specific gravity determinations.

The study was undertaken to determine how closely the mealiness of cooked potatoes judged by sensory means agreed with ratings based on specific gravity, and to evaluate the influence of varietal factors other than dry matter on the sensory judgment of mealiness.

PROCEDURE

The material used in this experiment consisted of seven selected varieties from the bulked replicates of a potato yield trial grown at Ames, Iowa, in 1952. The varieties used were Irish Cobbler, Red Warba, Chisago,

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[2] Agent, United States Department of Agriculture and Research Associate, Department of Horticulture, Iowa State College, Ames, Iowa.
[3] Formerly Horticulturist, Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, Iowa State College, Ames, Iowa. Present address: Department of Horticulture, Michigan State University, East Lansing, Mich.
[4] Professor, Home Economics Research, Iowa State College, Ames, Iowa.

Kennebec, Triumph, Sebago, and a seedling selection, X26-8. After harvest, the potatoes were placed in storage at approximately 40°F. until the cooking tests were performed.

In a previous investigation, Greenwood, McKendrick and Hawkins (2) used the mean specific gravity of an 8 to 10 tuber sample in determining the relationship between specific gravity and mealiness. In selecting tubers for cooking, preliminary tests showed that the specific gravity of uniformly sized, individual tubers of an 8 to 10 tuber sample of seven varieties, varied from a maximum of 1.053 to 1.099 for Kennebec to a minimum of 1.064 to 1.078 for Waseca. These results indicate that there could be a wide range in specific gravity of a sample used to judge mealiness if the average specific gravity was used to indicate the general mealiness of the group. Therefore, because of this variability, the tubers used in this study were tested individually for specific gravity.

One hundred pounds of each variety was divided into three specific gravity ranges: 1.065-1.075, 1.075-1.085, and 1.085-1.095 using the salt solution method described by Haddock and Blood (3).

Two tubers of approximately the same specific gravity from each of the seven varieties were baked for each evaluation. In addition, two tubers of Irish Cobbler representing the average specific gravity for the experiment (1.078-1.081) were included as controls to check the consistency of the judges, as shown in table 1. Two sets of eight tubers were used for each evaluation to overcome the problem of hollow heart.

Baking was chosen as the method of cooking because mealiness is a desirable attribute of a baked potato and because baking eliminates the factor of sloughing which may occur in boiled potatoes. Preliminary experiments had established that a baking temperature of 450°F. was satisfactory and that a potato was baked when its center temperature reached 210°F. A thermocouple was used to measure the center temperature of the most uniform set of potatoes used in each evaluation; and each tuber was removed from the oven when its internal temperature reached 210°F. The second set of tubers was baked at 450°F. for a specific period of time determined on the basis of correlation data as found in preliminary experiments.

After baking, a small slit was made with a knife in tubers from both sets to permit the escape of steam. Then the tubers were placed in a warming oven at 150°F. until all of the potatoes were baked. The most uniform set of tubers was cut into quarters and immediately given to the 3 judges on heated, individual dishes. The judging was conducted in standardized booths, each of which was lighted by four, 20-watt fluorescent lamps.

The five characteristics described by Sweetman (8) were used to evaluate mealiness in each of the potatoes used in the experiment. Arbitrary values of 1, 2, 3, and 4 were given the ratings of waxy, slightly mealy, moderately mealy, and very mealy, respectively. [See chart, page 344 in Sweetman (8).] The score for each tuber was totaled, and the totals analyzed statistically. Scores could range from a minimum of 5, which would indicate a non-mealy potato, to a maximum of 20 which would indicate a very mealy potato.

Results and Discussion

The average mealiness scores determined for cooked potato tubers in three specific gravity classes are significantly different among all the classes (Table 1). The data in table 1 indicate that, under the conditions used in this study, mealiness scores increased regularly from the lowest to the highest specific gravity class. The proportioning of the sums of squares due to regression also indicated that the relationship of specific gravity and mealiness is a direct and linear one. All samples in the higher specific gravity classes received higher mealiness scores (Table 1) except in the case of the variety Sebago.

Mealiness scores recorded in table 1 reveal highly significant differences between varieties averaged over the three specific gravity classes. This would indicate that certain varieties were consistently scored higher than others in mealiness regardless of specific gravity of the tubers being tested. The mean mealiness score of the standard variety, Irish Cobbler, was higher than the mealiness score for all other varieties. The difference between Irish Cobbler and Chisago was not significant; between Irish Cobbler and Red Warba it was significant at the 5 per cent level of probability, and between Irish Cobbler and the remaining four varieties the differences were significant at the 1 per cent level of probability.

The data in table 1 substantiate the well-known relationship between specific gravity and mealiness. However, at each specific gravity class there is a varietal difference in mealiness. Therefore, some character in addition to specific gravity appears to influence the mealiness of a potato variety as judged by the sensory methods employed with this panel. Although the specific gravity of potato tubers provides a convenient measure of total solids content and consequent mealiness within a variety, it is apparent that this characteristic should not be relied upon as an infallible measure for all varieties. The evidence secured from the use of a panel of judges indicates that some varietal characteristic causes judges to score certain varieties higher than others even when care is taken to select tuber samples having the same specific gravity. This is in agreement with the results published by Nylund and Poivan (*6*).

A characteristic such as flesh color, or the glistening of the starch particles may be the reason some varieties received a higher mealiness evaluation by the judges. It appears that mealiness, or quality, should be based upon the evaluation of a combination of factors, specific gravity or dry matter content alone is not sufficient. A similar conclusion was reported by Greenwood *et al* (*2*) who state that in evaluating the mealiness of new varieties of potatoes it would seem that sensory methods should be employed as well as specific gravity ratings until a more satisfactory objective method could be found.

Although the difference between the average mealiness scores for specific gravity classes is significant (Table 1), the mealiness scores for the variety Sebago seem to indicate that mealiness and specific gravity are not always directly related. Therefore, the variety Sebago may be worthy of further study to determine what characteristics, in addition to dry matter content, influence the mealiness of potatoes.

Another objective of this study was to investigate the probability that the specific gravity-mealiness relationship might remain constant up

TABLE 1.—*Mealiness scores for seven potato varieties and three specific gravity classes as determined by a panel of three judges.*

Specific Gravity Classes	Varieties							Specific Gravity Class Means	Control Mean[a]
	Irish Cobbler	Chisago	Red Warba	X20-8	Kennebec	Triumph	Sebago		
1.065-1.075	13.67[b]	14.22	11.33	11.22	10.00	11.78	11.67	11.98	12.67
1.075-1.085	17.22	14.78	12.22	13.11	14.67	11.44	8.67	13.59	13.44
1.085-1.095	18.00	17.89	15.67	15.89	15.00	13.22	10.56	15.18	11.89
Var. Means	16.30	15.63	14.07	13.41	13.22	12.15	10.30		
Differences between Var. Means and Irish Cobbler Mean	0.00	—.67	—2.23*	—2.89**	—3.08**	—4.15**	—6.00**		

Differences between Specific Gravity Class Means
(1.065 to 1.075) — (1.075 to 1.085) = 1.61*
(1.075 to 1.085) — (1.085 to 1.095) = 1.59*

LSD between Means for Varieties *2.13 **2.86
LSD between Means for Specific Gravity Classes *1.25

[a]The control consisted of the variety Irish Cobbler at the average specific gravity of the experiment (1.078-1.081). A sample of the control was judged with each specific gravity class at the same time these varieties were evaluated as a means of determining if judges were consistent from sample to sample.

[b]Means for three replications and three judges.

*Significant at the 5 per cent level of probability.

**Significant at the 1 per cent level of probability.

to a certain specific gravity level, and beyond that point the cooked potatoes might be judged to have uniform mealiness regardless of their specific gravity. An examination of the significance of the variance due to linear regression at the 1 per cent level of probability indicates that this is not true; at least it is not true over the range of specific gravities included in this study.

Summary and Conclusions

Seven potato varieties grown in Iowa were evaluated by a taste panel of three judges to determine the relationship of specific gravity of tuber samples and mealiness of the cooked product. The results indicated that differences between the mealiness scores for varieties averaged over all specific gravity classes were highly significant. Thus, there was some factor other than specific gravity that influenced the evaluation of mealiness by the judges. All of the judges were affected in the same way, since certain varieties were consistently scored higher in mealiness than others. Apparently specific gravity should be used in conjunction with other tests or observations in assessing mealiness of baked potatoes. A significant linear relationship was found between mealiness scores and specific gravity of potato tubers. The relationship between specific gravity of tuber samples and mealiness scores remained constant over the range of specific gravity used in this experiment. The judges were able to discern differences at the high, as well as the low range, of tuber specific gravity. The judges did not differ significantly in their ability to score mealiness by the sensory methods used. The statistical analysis of mealiness scores showed no significant differences due to judges, or to interactions of judges x varieties, and judges x specific gravity classes.

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SOME PHYSIOLOGICAL ASPECTS OF THE POTATO SCAB PROBLEM

I. Acidity and Aluminum[1]

G. V. C. Houghland and Lillian C. Cash[2]

Potato scab caused by *Streptomyces scabies*, is known to exist in some soils of practically every potato-growing district of the United States. Although in some cases the damage it causes may be only slight, the ultimate effects of a heavy infestation can be serious enough to make the commercial production of potatoes unprofitable. The serious aspects of the disease and its widespread occurrence have contributed to making scab a major problem that has engaged the attention of outstanding workers in several fields of research for a number of years. Potato scab, however, still remains a major disease problem despite recommended methods of control such as: (1) increasing the acidity of the soil, (2) establishing certain types of crop rotation, (3) growing scab-resistant varieties, (4) supplying certain elements or ratios of elements to the plant, and (5) applying fungicides to the soil.

The present paper concerns the effects of aluminum and acidity on the growth of the scab organism and scab control in the field. The effects of applying certain fungicides to the soil have been reported elsewhere (5) and the effects of calcium and the calcium-potassium ratio will be treated in a later paper.

Importance of Inoculation

Ordinarily the distribution of scab in potato fields is uneven so that for experimental work it usually is necessary to provide additional inoculation to get a more satisfactory uniform distribution of the organism. The use of scabby seed potatoes for this purpose is not always satisfactory because the chances are that the scabby seed pieces will not be located near enough to the newly-formed tubers to inoculate them readily. The same objection can be raised against the planting of seed potatoes that have previously been inoculated by scab culture.

Under field conditions the development and uniform spread of scab infestation usually requires more than one season. Some indications of the time required for the natural spread of the organism can be obtained from the work of Houghland and Strong (7). They treated 24 field plots successively over a period of years with neutral fertilizers containing as much as 380 pounds of limestone per ton. They noted that the first evidence of scab occurred in two of these plots during the fourth year. Thereafter scab occurred in five plots during the fifth year and in 16 of the 24 plots in the sixth year. Even though lime was applied in the fertilizer each year, the rate of scab development was slow. In the seventh year one row of each plot was planted with inoculated seed, as reported by Cook and Houghland (3). No appreciable increase in the amount of scab was found in the inoculated rows as compared with the adjoining uninoculated ones. In contrast, a field at Beltsville, Maryland, was

[1]Accepted for publication November 2, 1955.
[2]Biochemist and Assistant Pathologist, Horticultural Crops Research Branch, Agricultural Research Service, U.S.D.A., Beltsvillle, Md.

inoculated in 1950 by the soil-infestation method described by Houghland and Cash (6) and an average of 48 per cent scabby potatoes was produced the first year. Good distribution of the initial inoculation was obtained and it continued to be effective for more than four years. These results serve to indicate the superiority of using a soil-infestation method compared with the use of scabby or inoculated seed potatoes.

Soil Reaction

Increasing the acidity of the soil is generally considered an effective means of controlling potato scab but on some soils higher acidity is not always effective enough to produce a satisfactory percentage of marketable potatoes. Appreciable increases in soil acidity can be obtained in some soils by applying finely ground sulfur or by using acid-forming fertilizers. However, with alkaline soils acid-forming treatments are more often ineffective and also expensive because of the large amounts of the materials that have to be applied to get results. Potatoes have a wide soil reaction range so that yields are seldom adversely affected directly by moderately high soil acidity. Where high acidity persists the real danger to the crop is from deficiencies of the secondary elements calcium and magnesium rather than from the direct effects of acidity. The writers have obtained excellent vine growth and tuber development with potatoes growing in solution cultures at reactions as low as pH 3.5. Reactions below pH 4.8 are seldom encountered in potato soils.

For many years soils with reactions of pH 5.2 or lower have generally been considered safe from the scab standpoint but this seems no longer true because instances of scab are being reported in fields with reactions of pH 4.8, a common reaction for potato soils in parts of the East. Blodgett and Howe (2) reported finding as much as 6 per cent scab in soils ranging in reaction from pH 4.5 to 4.9 but this percentage was increased 3 to 5 times at reactions up to pH 8.0, after which there seemed to be a decrease. According to Schaal (11) variations are occurring in the scab organism and since he reported strains of *Streptomyces scabies* causing scab at pH 5.4, it would seem probable that other strains may be responsible for scab at pH 4.8 or possibly even lower reactions. Martin (9) obtained 40.7 per cent and 35.6 per cent scabby potatoes in soil with a reaction of pH 4.8.

Aside from the possible influence of specific strains and the direct effects of soil acidity, there are other factors which may influence the development of scab in acid soils. One such factor, hydrogen sulfide, was demonstrated by Vlitos and Hooker (12) to be effective in reducing the growth of *Streptomyces scabies* and hydrogen sulfide was actually found present in scab-infested soil treated with sulfur. Another factor, soluble aluminum for some time has been suspected of depressing the growth of the scab organism in acid soils. Gries (4), using strains of *Streptomyces scabies* capable of growing at pH 4.2 to 4.3, was able to inhibit growth at pH 5.2 in the presence of 16 p.p.m. of aluminum.

According to Magistad (8), aluminum as a cation is highly water soluble at pH 3.9, gradually becoming insoluble as pH 7.0 is approached and again increasing in solubility as an anion above pH 7.0. Gries (4) suggested that this solubility characteristic of aluminum offered a possible

explanation for the decrease of potato scab in very acid and in alkaline soils.

Experimental Results

A series of tests was conducted by the writers to determine the effects of aluminum on the growth of *Streptomyces scabies* in pure culture. Table 1 gives the results of tests with aluminum chloride and with hydrochloric acid added to potato-dextrose agar in increasing amounts. Growth of the organism was at first slow but eventually all cultures produced very good growth, except those receiving 160 p.p.m. of aluminum. It will be noted that the reaction of this particular medium was pH 4.6 after sterilization and remained practically unchanged for 26 days. In every case where growth occurred, however, it will be noted that there was a pronounced increase in the pH of the media. After 26 days the reaction was increased from pH 4.7 to 6.3 to approximately pH 8.0. Afanasiev (1) found that after 43 days the reaction of media inoculated with different cultures of *Actinomyces* was pH 8.4+.

The ability to increase the pH of the media exhibited by *Streptomyces scabies* in table 1 is believed to be significant in relation to the occurrence of scab in localized spots in acid potato soils. It is entirely possible that the organism, once it has commenced to grow in such a soil, may alter the pH of its immediate environment and thus become established in the field. Walker (13) has suggested that the reaction of the soil immediately surrounding the potato tubers may differ considerably from that of the entire field, thus providing a localized condition favorable for scab development. Sanford (10) also suggested that the acidity close to the tubers might be reduced sufficiently to allow scab development in acid soils. In support of this suggestion he cites the work of Martin (9) who obtained scab on 20.6 and 89.6 per cent of the tubers in soils of pH 4.2 and 4.8, respectively.

Similar pure culture tests were run with 25 to 100 p.p.m. of aluminum

Table 1.—*The effects of aluminum chloride* ***and hydrogen-ion*** *on the growth of Streptomyces scabies.*

Treatment Solutions[1]	Reaction of Media		Growth of *S. scabies*		
	After Sterilization	26 Days after Inoculation	3 Days	7 Days	26 Days
	pH	*pH*			
100 p.p.m. Al.	5.2	8.2 - 8.3	None	Good	Very Good
120 p.p.m. Al.	4.7	8.0 - 7.8	None	Fair	Very Good
160 p.p.m. Al.	4.6	4.5	None	None	None
HCl 0.01 N	5.2	8.3 - 8.6	None	Good	Very Good
HCl 0.001 N	6.1	8.5	Good	Very Good	Very Good
Control. No Al. or HCl	6.3	8.7	Good	Very Good	Very Good

[1]75 cc of each solution added to 75 cc potato-dextrose agar. Aluminum from $AlCl_3.12H_2O$.

from aluminum acetate (basic), aluminum tartrate, and aluminum citrate added to potato agar. All cultures were inoculated with *Streptomyces scabies* and after 28 days growth was light or failed completely at 100 p.p.m., medium at 80 p.p.m. but was medium to heavy at all lower concentrations. Here, again, where growth failed, the reaction ranged from pH 5.1 to 5.2 which was lower than that for any other treatment in the series ranging from pH 5.3 to 6.1. Figure 1 shows the effects of

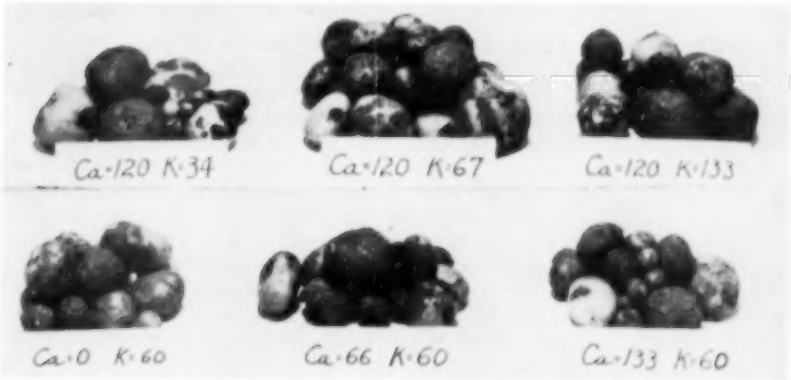

FIGURE 1.—Effects of aluminum acetate on the growth of *Streptomyces scabies* in potato agar. (1), Control; (2), 26 p.p.m. Al; (3), 50 p.p.m. Al; (4), 60 p.p.m. Al; (5), 80 p.p.m. Al; and (6), 100 p.p.m. Al.

adding various amounts of aluminum acetate to a series of cultures which later were inoculated with *S. scabies*. The organic aluminum salts appeared to be a little more effective on the growth of the organism than the inorganic salt, aluminum chloride.

EFFECT OF ALUMINUM IN SOIL

Tests on the effectiveness of aluminum in controlling potato scab in soil were conducted on a half-acre field at Beltsville, Maryland. The soil is a medium-heavy silty clay loam that has a tendency to be on the "wet side" during seasons of normal rainfall and has supplied adequate moisture for a normal potato crop during a dry season. The field was first inoculated with the scab organism in April 1950, according to the procedure outlined by Houghland and Cash (6) prior to planting potatoes as a uniformity test crop. An average of 48 per cent scabby potatoes was obtained from this inoculation the first season and the distribution of the organism in the field as judged from the results of the uniformity test, was considered satisfactory.

In 1951 an experiment to determine the effects of aluminum was laid out in randomized block design on this field. The layout consisted of 3 blocks containing 5 treatment plots, each consisting of 2 rows, 100 feet long with a guard row between plots. The initial soil reaction in 1950 was pH 4.3 before lime was applied and pH 5.3 at planting time in 1951.

Finely ground aluminum sulfate in amounts sufficient to supply

different quantities of aluminum was mixed with sand and these mixtures were applied just before planting in bands about 18 inches wide centered on the row mark. Mixing was done with a cultivator and the potatoes were planted with a one row planter calibrated to apply 1800 pounds per acre of 5-10-5 fertilizer placed in bands. This method of applying the aluminum sulfate ultimately deposited it in the soil mixture above and around the potato seed piece.

The plot treatments were permanently located so that in 1951 and 1952, similar aluminum treatments were applied to the same plots. The Katahdin variety of potato was planted each season and rye was seeded for a green-manure crop after the potatoes were dug.

The results from the field experiment given in table 2 indicate that the aluminum sulfate was ineffective in controlling potato scab even at the rate of 800 pounds per acre applied for two successive seasons. This result was undoubtedly due to the fact that the aluminum sulfate failed to increase the acidity of the soil. The initial reaction of the soil was pH 5.3 and after applying aluminum sulfate at 800 pounds per acre for two successive seasons, the reaction was pH 5.8. Larger applications might have been effective but the use of these would be governed by economic considerations. Gries (4), working on muck, concluded that amounts of aluminum sulfate required to control potato scab would be uneconomical. The potato plant, however, is apparently not highly sensitive to aluminum because the writers obtained good yields of tubers, dry matter, and starch when potato plants were grown in solution cultures containing 20 p.p.m. of aluminum.

Summary and Conclusions

The superiority of the soil-infestation method for providing suitable

Table 2.—*Yield and percentage of scabby potatoes by weight and soil reaction before and after successive applications of aluminum sulfate.*

$Al_2(SO_4)_3 \cdot 18\,H_2O$ per Acre	Yield and Per cent Scabby Potatoes and Soil Reaction in —						
	1950*		1951			1952	
	Yield per Acre**	Scabby Potatoes	Yield per Acre**	Scabby** Potatoes	Soil Reaction	Scabby*** Potatoes	Soil Reaction
Lbs.	Bus.	Per cent	Bus.	Per cent	pH	Per cent	pH
None	98.4	47.5	192.9	75.6	5.5	96.6	6.1
100	95.5	45.1	147.9	53.4	5.3	94.8	5.7
250	117.7	54.5	194.4	67.1	5.8	97.7	6.0
500	109.9	45.7	167.5	58.6	5.1	95.5	5.9
800	114.8	47.4	150.0	51.7	5.1	81.8	5.8
C.V. (Per cent)	2.9	3.1	2.0	7.7	..	4.1	..

*No aluminum treatments in 1950; first applied in 1951. Initial soil reaction pH 5.3.
**Differences not significant.
***Spring planting failed; yields of fall planting not recorded; scab readings made on 30-pound sample from each plot.

distribution of scab in potato fields for experimental purposes was pointed out and results from this method were compared with those from the use of scabby or inoculated seed pieces.

Two series of culture tests were conducted to determine the effects of inorganic and organic aluminum salts on the growth of *Streptomyces scabies*, whereas a third series was run with additions of hydrochloric acid in different concentrations. Growth was found inhibited at the 100 p.p.m. concentration of aluminum from organic salts and at 160 p.p.m. from aluminum chloride.

Wherever growth of the organism took place, it was accompanied by a pronounced reduction in the acidity of the media, ranging from pH 4.7 and 6.3 to approximately pH 8.0 in 26 days. This characteristic of *S. scabies*, it was suggested, could account for the development of scab in localized spots in potato fields with reactions of pH 4.8 to 5.2.

An experiment comparing different amounts of aluminum sulfate applied for two successive seasons to scab-infested land, failed to control the scab even at the highest application, 800 pounds per acre. The aluminum sulfate had little or no effect in lowering the pH of the soil and although larger amounts might have been more effective, it was concluded that these would be uneconomic.

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A NOTE ON THE COLOR DEVELOPMENT IN POTATO CHIPS SUBSEQUENT TO GROWTH OF *PENICILLIUM EXPANSUM* ON THE CUT SURFACES OF POTATOES[1]

D. K. Salunkhe and L. H. Pollard[2]

In potato storage, it has been observed that the bruised potatoes infested with *Penicillium expansum* (Link) yield chips of dark brown color, whereas healthy potatoes of the same variety produce chips of acceptable golden yellow color.

The purpose of this investigation was to study the growth of *Penicillium expansum* on the longitudinally cut surface of potatoes and its influence on color of their chips.

Ten U.S. No. 1 potatoes of Russet Rural variety were selected for this experiment. They were surface sterilized with 5 per cent mercuric chloride solution and were transferred to the sterile room. Potatoes were then cut longitudinally into two halves. The cut surface of one of the halves of each potato was atomized with distilled water to serve as a control lot and other halves were inoculated (atomized) with a water suspension of spores of *Penicillium expansum*. Immediately following treatments, the respective lots were stored for 30 days in separate chambers at 70°F. and at 20 per cent relative humidity.

The cut surfaces of the control lot were callused and dried at the end of the storage period. Profuse growth of *Penicillium expansum* on the treated surface was noted in the region of the stele, whereas very little or no apparent growth occurred in the cortical region. This may have been caused by variations in the water content of the two regions, or by the presence of certain chemicals in the stele essential for the growth of *Penicillium expansum* or the absence of such chemicals, or presence of some other chemicals in the cortex which inhibited the growth of the fungus.

Potato chips from the two lots were made at the end of the storage period after removing a ½-inch segment of the surface. A standard method of chip making (1) was used. Chips from the control lot were of uniform golden yellow color, whereas from the fungus inoculated lot they were of dark color in the stele. This dark color development in potato chips can be attributed to the effect of chemicals secreted by *Penicillium expansum* which may have altered the chemical makeup of potatoes, which in turn assisted in the formation of dark pigment in their chips.

[1]Accepted for publication October 12, 1955.

[2]Assistant Professor and Professor, respectively; Department of Horticulture, Utah State Agricultural College, Logan, Utah.

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NEWS AND REVIEWS

POTATO GROWING IN CALIFORNIA[1]

FRANCIS P. PUSATERI[2]

USDA statisticcs indicate that in both the early and late potato areas of California (1955 season) producers farmed about 118,000 acres, which yielded approximately 50,255,000 bushels (Table 1). This production will be exceeded only by the State of Maine with an expected 68,200,000 bushels, and will slightly exceed Idaho, which will produce an esimated 49,225,000 bushels. The seasonal value of potatoes in California in 1954 was an estimated $63 million, compared with $40 million in 1953 and $102 million in 1952, harvested from 39 of California's 58 counties.

The most important consideration in order to accomplish the successful production of potatoes in California, as in other major producing areas, is the planting of certified, disease-free seed. Regardless of the excellence of general cultural practices, high yields and proper quality cannot be achieved unless good seed is planted.

Practically all the potato acreage planted in the state utilizes certified seed, grown chiefly in the States of California, Oregon, Washington, Idaho, Montana, Minnesota and North Dakota.

SEED TREATMENT

Several different treatments for potato seed are employed, no one of which can be termed "superior" in all circumstances. The choice of seed treatment depends upon the producer and also, to a large extent, on the facilities he has available. Some of the treatments used include the following:

1. Corrosive sublimate (mercuric chloride)
2. Hot corrosive sublimate
3. Acidulated corrosive sublimate
4. Hot formaldehyde
5. Propriety organic mercury compounds (Several different compounds of this nature are on the market. Among the best known are Ceresan, New Improved Ceresan, Semesan (several types) and Merco.

CORROSIVE SUBLIMATE IS A DEADLY POISON AND EXTREME CARE MUST BE EXERCISED IN ITS USE.

PLANTING

As a rule, potatoes mature best in a relatively cool climate, yet high yields and good quality are acheived in certain California areas where high temperatures occur during the growing season. Temperatures of 60° to 75° F. are generally thought to be the most favorable for planting and best tuber development. In the southern areas, however, where daytime temperatures frequently go above 100° F., growers obtain extremely high yields by employing proper cultural practices. When air temperature is high, soil temperature can be kept relativeley low by freequent irrigation.

[1]Accepted for publication December, 5, 1955.

[2]Executive Secretary-Manager, Kern County Potato Growers' Association, Bakerfield, Cal.

TABLE 1.—*California acreage estimates and 1955 production forecasts.*

	Harvest (Acres)			Yield per Acre (Bu.)		Production (Bushels)		
	10-Yr. Aver. 1944-53	1954	For Harv. 1955	1954	Indicated 10-1-55	10-Yr. Aver. 1944-53	1954	Indicated 10-1-55
Early	70,000	57,000	69,000	400	465	27,770,000	22,800,000	32,085,000
Summer	13,500*	12,000	13,000	440	470	5,773,000*	5,280,000	6,110,000
Fall	27,500*	34,000	36,000	298	335	9,581,000*	10,130,000	12,060,000
Totals	111,000	103,000	118,000		-	43,124,000	38,210,000	50,255,000

*5-Yr. Average

The principal districts producing potatoes in California are outlined in table 2. As this chart shows, the White Rose or "Long White" variety is the most popular potato produced in California.

Planting of potatoes in California takes place from December through August of the succeeding year. The operation is accomplished by machine, with from one to four rows being planted simultaneously, with accurate and uniform spacing. From 12 to 20, 100-lb. sacks of seed are used to the acre. The quality depends not only on the size of the seed piece but also upon the spacing—between rows and between seed pieces. The planting depth varies from 4 to 6 inches.

Fertilization

The best soils must, of course, be very fertile, well-drained, and of rather loose texture. Excellent results in California are obtained in sandy loam, silt loam and peat type soils. A good crop is the result of high fertility, which usually means the application of sufficient fertilizer, table 3. Experiments in Kern County (largest potato producing area in the State) reveal that one crop of potatoes will remove from the soil 125 to 200 pounds of nitrogen, about 60 pounds of phosphoric acid, and approximately 300 pounds of potash. The addition of plant nutrients in any of the many forms available is therefore necessary for the production of a satisfactory potato crop. The addition of organic fertilizer and humus, such as manure and cover crops, has proved extremely beneficial.

Irrigation

Practically every known irrigation practice is used in the different districts of California. These methods include: culture under winter rains; dry farming summer culture; irrigation on alternate days; and nearly-continuous sub-irrigation. The method depends on the particular area. Overhead irrigation is also used in certain sections. Normally, a total application of approximately 30 acre-inches of water are required to produce early potatoes and about 20 acre-inches for the late crop.

Harvesting

At harvest time potatoes are dug by so-called "mechanical harvesters" or by "digger" machines of either the one-row or two-row type, equipped in most instances with a roller. This roller extends the width of the machine and replaces the rear wheels. It breaks down the clods and smooths the soil that is distributed by the plow section of the digger, resulting in an even, compact surface upon which the potatoes drop. The newly harvested potatoes, in most operations, are then picked from the ground by hand and placed in canvas "half-sacks" or "stubs". The canvas affords considerable protection from the wind and sun for a reasonable period, until the packing shed is reached. (Figure 1)

Mechanical harvesting is employed in certain areas throughout the state with varying degrees of success. The major difficulty in this process is the accumulation of clods, usually in heavier-type soils, which mix with the potatoes during the operation, resulting in some bruised tubers. On the whole, significant progress and success have been made in mechani-

TABLE 2.—*Potato Growing Districts in California.*

District	1955 Acreage		Approx. Dates of Planting		Approx. Dates of Harvest		Principal Varieties Grown
	Early	Late	Early	Late	Early	Late	
Riverside and San Bernardino Counties	11,200	8,600	March	July through August	July	December through February	White Rose
Upper San Joaquin Valley: Kern Tulare, Fresno, Madera, Merced, Kings Counties	57,700	11,525	December through April	August through September	April through July	December through March	White Rose
Santa Maria Area: Santa Barbara, San Luis Obispo, Ventura Counties		4,225		April through May		August through October	White Rose Russet
Monterey County (Salinas)		1,200		April through May		August through October	White Rose Russet
Delta Area (Stockton): San Joaquin County		7,500		April		August through October	White Rose Russet Burbank
Tulelake Area: Siskiyou and Modoc Counties		11,910		May		October	White Rose Russet
Remaining Counties	,100	4,040					
Total Early and Late Acreage	69,000	49,000					
Total State Acreage	118,000						

FIGURE 1.—Harvesting potatoes in California.

TABLE 3.—*Summary of fertilizer recommendations for the principal potato production areas of California.*

Area	Fertilizer Parts of Nitrogen-Phosphorus-Potassium	Rate of Application Pounds per Acre
Upper San Joaquin Valley	20-0-0 or 16-20-0 or 17-7-0	600
Riverside-San Bernardino	20-0-0 or 16-20-0 or 17-7-0	600
Tulelake	16-20-0 or 11-48-0	400
Delta	10-10-10 (on older fields) 0-10-10 (on new or burned-over land)	500 to 1000 500 to 1000
Misc. Mountain Areas	16-20-0	600
Misc. Coastal Areas	20-0-0	600

cal harvesting studies and applications in the various areas during the past three years. It is felt that the clod problem can be eliminated and optimistic predictions estimate that these machines will be commonplace within the next four or five years.

Packing and Shipping

Potato acreage under production by a single grower may vary from 10 to 5000 acres. 300 to 500 acre operators are rather common, especially in the Kern area.

On arrival at the packing shed, California potatoes are put through a rather complicated machine which handles them carefully and gently, and usually includes a washer with special-type revolving brushes and efficient water sprays. The potatoes are then sized and conveyed on divided endless-belts past human hand graders who sort and pick out the tubers until each division of the belt contains a single grade. The tubers drop from the end of the respective grading belts into containers of varying capacities—either 100, 50, 25, or 10 pounds each. Operators filling burlap bags, check the weight of each bag, insert shims, sew the sacks and transfer to cars or trucks for shipment. Containers of mesh, paper, polyethylene, baskets, fibrebox, and wirebound crates are generally utilized, for net weights of less than 100 pounds.

The more efficient operators are quipped to grade one carload (360, 100-lb. bags) in 12 to 15 minutes. At the peak of the harvest in the Kern District, 700 to 1200 carloads are moved in each 24-hour period, at which time at least 10,000 persons are employed in harvesting, hauling, packing, loading and transporting the product. More than 50 per cent of the approximatelly 35,000 carlot equivalents produced each season in this area moves in to markets east of the Mississippi, as well as to Canada, Mexico and Hawaii.

Marketing

During 1955, two separate state marketing orders were in operation—one covering nine counties in the central and southern areas of the state and another applying to the Delta Area of Stockton. A federal order also applied to the northern area of the state in Siskiyou and Modoc Counties. Despite the fact that various marketing orders are in effect throughout the various areas of the state, the California minimum standardization law for potatoes (among the highest in the nation) is practically equal to the federal U.S. No.2 grade (Sec. 818 Ch. 1 Div. 5, Calif. Ag. Code). California has only one state grade for potatoes, designated as "California Standard", which must meet at least the minimum requirements of 85 per cent U.S. No. 1 federal grade.

All Purpose Potato

As previously pointed out, the variety produced in greatest volume throughout the state, is the White Rose, more commonly known as the "Long White". It is a clean, smooth, shallow-eyed, thin-skinned, light-colored and elongated tuber. It falls approximately in the middle of the Specific Gravity range for potatoes, with an average rating of 1,082.

and therefore lends itself to "all purpose" preparations, including boiling, mashing, frying and baking. Its characteristic sugar content produces a preferred color when frying and its desirable mealiness produces an excellent baker without being too dry. Pastry cooking employs the California "Long White" in the preparation of potato cake and pie, which are gaining rapidly in national popularity.

Research

The following departments of the University of California conduct comprehensive potato research programs: Vegetable Crops Department on the Davis, California campus; Irrigation Department at Davis; Plant Pathology and Entomology Departments at Davis, Berkeley and Riverside; Nematology Department and Agricultural Engineering Departments at Davis, and Agricultural Economics Department at Davis and Berkeley.

Some of the work currently under study by the Vegetable Crops Department consists of: (1) Tests of new and selected varieties for yield and chipping quality; (2) Breeding varieties and seedlings for resistance to scab and verticillium wilt; (3) Effect of area of production of seed potatoes and storage conditions on yield ability; (4) Seed piece size and spacing; (5) Depth of planting and height of bed; (6) Effect of soil acidification on phosphorus availability; (7) Effect of rates, sources, gaseous *vs.* dry forms, placement and timing of nitrogen, phosphoric acid and potash feritlizers on yield, composition, grade and storability; (8) Effect of rotation involving certain soil-improving and cash crops, on the yield of potatoes and scab development; (9) Effect of soil conditions as related to mechanical harvesting, and (10) Handling, packaging, storage and transportation studies.

The Irrigation Department is conducting research on: (1) Irrigation of potatoes; (2) Water quality; (3) Water penetration of potato soils, other than influenced by quality; (4) Fertilizers as influenced by irrigation, and (5) Soil management to improve production.

Plant Pathology laboratories are investigating: (1) Control of potato scab; (2) Cause and control of black leg of potatoes; (3) Potato virus studies; (4) Studies on the causes of hairsprout of potato; (5) Studies on internal browning of Netted Gem potatoes; (6) Studies on control of potato leak, and (7) Potato seed piece treatment trials.

Entomologists of the University are in the midst of Project No. 1560, begun in April 1953, to study insect problems of potatoes in northern California. A section is also working on the same problem in southern California. At Tulelake, in 1954, they investigated the feasibility of controlling leaf roll virus in seed fields by the control of the green peach aphid. Wireworm control studies have been under way for three years.

The Nematology Department conducts continuous investigations on the important problem of nematode control.

Supply and Demand

The recent trends in the supply and demand in Kern County and their effect on F.O.B. prices are shown in figure 2.

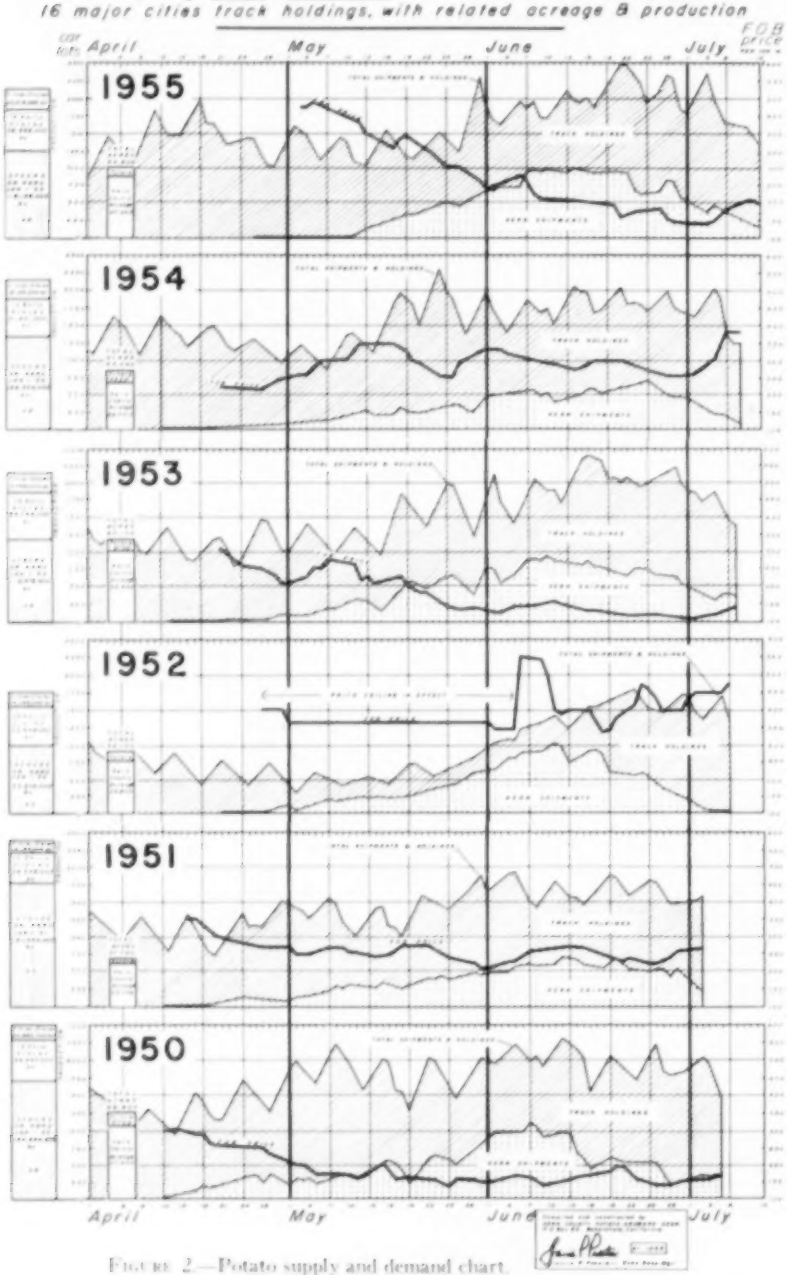

FIGURE 2.—Potato supply and demand chart.

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Conciseness and practicability have been the primary consideration in writing this book.

Since the majority of research personnel even in this enlightened age have had no more than a single course in statistics this book of examples should be a very useful aid in planning, analyzing, and interpreting, experimental data.

Where really expert statistical advice is unavailable this book can do much to dispel many of the uncertainties which the beginners in research are bound to encounter in their use of statistical procedures.

Copies are available from Nellie Landblom, P. O. Box 248, Fort Collins, Colorado, at $2.95 per copy.—*John C. Anderson*

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